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An American National Standard

Product Data Exchange Using STEP
Part 1 – Overview and Fundamental Principles

This document is the ANSI adoption of the International Standard ISO 10303-1:1994. The contents of these two documents are identical.

U.S. Product Data Association

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INTERNATIONAL STANDARD

ISO 10303-1

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Industrial automation systems and integration — Product data representation and exchange —

Part 1: Overview and fundamental principles

Systèmes d'automatisation industrielle et intégration — Représentation et échange de données de produits —

Partie 1: Aperçu et principes fondamentaux

Reference number
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Contents

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Foreword

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

International Standard ISO 10303–1 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration,* Subcommittee SC4, *Industrial data and global manufacturing programming languages.*

ISO 10303 consists of the following parts under the general title *Industrial automation systems and integration – Product data representation and exchange:*

- Part 1, Overview and fundamental principles;
- Part 11, Description methods: The *EXPRESS* language reference manual;
- Part 21, Implementation methods: Clear text encoding of the exchange structure;
- Part 22, Implementation methods: Standard data access interface specification;
- Part 31, Conformance testing methodology and framework: General concepts;
- Part 32, Conformance testing methodology and framework: Requirements on testing laboratories and clients;
- Part 41, Integrated generic resources: Fundamentals of product description and support;
- Part 42, Integrated generic resources: Geometric and topological representation;
- Part 43, Integrated generic resources: Representation structures;
- Part 44, Integrated generic resources: Product structure configuration;
- Part 45, Integrated generic resources: Materials;
- Part 46, Integrated generic resources: Visual presentation;
- Part 47, Integrated generic resources: Shape variation tolerances;
- Part 49, Integrated generic resources: Process structure and properties;

- Part 101, Integrated application resources: Draughting;
- Part 104, Integrated application resources: Finite element analysis;
- Part 105, Integrated application resources: Kinematics;
- Part 201, Application protocol: Explicit draughting;
- Part 202, Application protocol: Associative draughting;
- Part 203, Application protocol: Configuration controlled design;
- Part 207, Application protocol: Sheet metal die planning and design;
- Part 210, Application protocol: Printed circuit assembly product design data;
- Part 213, Application protocol: Numerical control process plans for machined parts.

The structure of this International Standard is described in ISO 10303-1. The numbering of the parts of this International Standard reflects its structure:

- Part 11 specifies the description methods;
- Parts 21 and 22 specify the implementation methods;
- Parts 31 and 32 specify the conformance testing methodology and framework;
- Parts 41 to 49 specify the integrated generic resources;
- Parts 101 to 105 specify the integrated application resources;
- Parts 201 to 213 specify the application protocols.

Should further parts be published, they will follow the same numbering pattern.

Annex A forms an integral part of this part of ISO 10303. Annex B is for information only.

Introduction

The information generated about a product during its design, manufacture, use, maintenance, and disposal is used for many purposes during that life cycle. The use may involve many computer systems, including some that may be located in different organizations. In order to support such uses, organizations need to be able to represent their product information in a common computer-interpretable form that is required to remain complete and consistent when exchanged among different computer systems.

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

ISO 10303 is organized as a series of parts, each published separately. The parts of this International Standard fall into one of the following series: description methods, integrated resources, application protocols, abstract test suites, implementation methods, and conformance testing.

This part of ISO 10303 provides an overview. It specifies the functions of the various series of parts of ISO 10303 and the relationships among them.

Industrial automation systems and integration — Product data representation and exchange — Part 1 : Overview and fundamental principles

1 Scope

This part of ISO 10303 provides an overview of this International Standard.

This International Standard provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle, including product design, manufacture, use, maintenance, and final disposition of the product.

The following are within the scope of ISO 10303:

- the representation of product information, including components and assemblies;
- the exchange of product data, including storing, transferring, accessing, and archiving.

This part of ISO 10303 defines the basic principles of product information representation and exchange used in ISO 10303. It specifies the characteristics of the various series of parts of ISO 10303 and the relationships among them.

The following are within the scope of this part of ISO 10303:

- an overview of this International Standard;
- the structure of this International Standard;
- definitions of terms used throughout this International Standard;
- an overview of data specification methods used in this International Standard including the *EXPRESS* data specification language and graphical presentation of product information models;
- an introduction to the integrated resources;
- an introduction to application protocols that are used to define the scope, context, and information requirements of an application, and the representation of the application information;
- an introduction to the methodology and framework for conformance testing that provides an assessment of whether an implementation conforms to this International Standard;

– an introduction to the abstract test suites to be used as a basis for conformance testing;

– an introduction to the implementation methods which may be used with this International Standard.

The scopes of the other parts of ISO 10303 are defined within those parts.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10303. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10303 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 10303-31:1994, *Industrial automation systems and integration – Product data representation and exchange – Part 31: Conformance testing methodology and framework: General concepts.*

ISO/IEC 8824-1:–[1)], *Information technology – Open Systems Interconnection – Abstract Syntax Notation One (ASN.1) – Part 1: Specification of Basic Notation.*

3 Definitions and abbreviations

3.1 Terms defined in ISO 10303-31

This part of ISO 10303 makes use of the following terms defined in ISO 10303-31:

– abstract test case

– abstract test method

– conformance testing

– test purpose

– verdict

– verdict criteria

[1)] To be published.

3.2 Other definitions

For the purposes of ISO 10303, the following definitions apply.

3.2.1 abstract test suite: a part of this International Standard that contains the set of abstract test cases necessary for conformance testing of an implementation of an application protocol.

3.2.2 application: a group of one or more processes creating or using product data.

3.2.3 application activity model (AAM): a model that describes an application in terms of its processes and information flows.

3.2.4 application context: the environment in which the integrated resources are interpreted to support the use of product data in a specific application.

3.2.5 application interpreted model (AIM): an information model that uses the integrated resources necessary to satisfy the information requirements and constraints of an application reference model, within an application protocol.

3.2.6 application object: an atomic element of an application reference model that defines a unique concept of the application and contains attributes specifying the data elements of the object.

3.2.7 application protocol (AP): a part of this International Standard that specifies an application interpreted model satisfying the scope and information requirements for a specific application.

NOTE – This definition differs from the definition used in open system interconnection (OSI) standards. However, since this International Standard is not intended to be used directly with OSI communications, no confusion should arise.

3.2.8 application reference model (ARM): an information model that describes the information requirements and constraints of a specific application context.

3.2.9 application resource: an integrated resource whose contents are related to a group of application contexts.

3.2.10 assembly: a product that is decomposable into a set of components or other assemblies from the perspective of a specific application.

3.2.11 component: a product that is not subject to decomposition from the perspective of a specific application.

3.2.12 conformance class: a subset of an application protocol for which conformance may be claimed.

3.2.13 conformance requirement: a precise, text definition of a characteristic required to be present in a conforming implementation.

3.2.14 data: a representation of information in a formal manner suitable for communication, interpretation, or processing by human beings or computers.

3.2.15 data exchange: the storing, accessing, transferring, and archiving of data.

3.2.16 data specification language: a set of rules for defining data and their relationships suitable for communication, interpretation, or processing by computers.

3.2.17 exchange structure: a computer-interpretable format used for storing, accessing, transferring, and archiving data.

3.2.18 generic resource: an integrated resource whose contents are context-independent.

3.2.19 implementation method: a part of this International Standard that specifies a technique used by computer systems to exchange product data that is described using the *EXPRESS* data specification language [ISO 10303-11].

3.2.20 information: facts, concepts, or instructions.

3.2.21 information model: a formal model of a bounded set of facts, concepts or instructions to meet a specified requirement.

3.2.22 integrated resource: a part of this International Standard that defines a group of resource constructs used as the basis for product data.

3.2.23 interpretation: the process of adapting a resource construct from the integrated resources to satisfy a requirement of an application protocol. This may involve the addition of restrictions on attributes, the addition of constraints, the addition of relationships among resource constructs and application constructs, or all of the above.

3.2.24 PICS proforma: a standardized document in the form of a questionnaire, which, when completed for a particular implementation, becomes the protocol implementation conformance statement.

3.2.25 presentation: a recognizable visual representation of product data.

3.2.26 product: a thing or substance produced by a natural or artificial process.

3.2.27 product data: a representation of information about a product in a formal manner suitable for communication, interpretation, or processing by human beings or by computers.

3.2.28 product information: facts, concepts, or instructions about a product.

3.2.29 product information model: an information model which provides an abstract description of facts, concepts and instructions about a product.

3.2.30 protocol implementation conformance statement (PICS): a statement of which capabilities and options are supported within an implementation of a given standard. This statement is produced by completing a PICS proforma.

3.2.31 resource construct: a collection of *EXPRESS* language entities, types, functions, rules and references that together define a valid description of an aspect of product data.

3.2.32 structure: a set of interrelated parts of any complex thing, and the relationships between them.

3.2.33 unit of functionality: a collection of application objects and their relationships that defines one or more concepts within the application context such that removal of any component would render the concepts incomplete or ambiguous.

3.3 Abbreviations

For the purposes of this part of ISO 10303, the following symbols and abbreviations apply.

AAM	application activity model.
AIM	application interpreted model.
AP	application protocol.
ARM	application reference model.
PICS	protocol implementation conformance statement.

4 Overview of ISO 10303

4.1 Purpose

The purpose of ISO 10303 is to specify a form for the unambiguous representation and exchange of computer-interpretable product data throughout the life of a product. This form is independent of any particular computer system. This form enables consistent implementations across multiple applications and systems. This International Standard permits different implementation methods to be used for storing, accessing, transferring, and archiving product data. Implementations can be tested for conformance.

4.2 Fundamental principles

ISO 10303 separates the techniques of representation of product information from the implementation methods used for data exchange.

The representation techniques provide a single representation of product information common to many applications. This common representation can be tailored to meet the needs of specific applications. An application protocol specifies the representation of product information for one or more applications.

ISO 10303 specifies the implementation methods that support the exchange of product data defined in application protocols.

ISO 10303 defines a formal data specification language, *EXPRESS* which is used to specify the representation of product information. The use of a formal language provides unambiguous and consistent representation and facilitates development of implementations.

ISO 10303 provides a methodology and framework for conformance testing of implementations.

4.2.1 Integrated resources

The specification of a representation of product information is provided by a set of integrated resources. Each integrated resource comprises a set of product data descriptions, written in *EXPRESS* known as resource constructs. One set may be dependent on other sets for its definition. Similar information for different applications is represented by a single resource construct.

The integrated resources are divided into two groups: generic resources and application resources. The generic resources are independent of applications and can reference each other. The application resources can reference the generic resources and can add other resource constructs for use by a group of similar applications. Application resources do not reference other application resources.

4.2.2 Support for applications

The integrated resources define a generic information model for product information. They are not sufficient to support the information requirements of an application without the addition of application specific constraints, relationships and attributes.

ISO 10303 defines application protocols in which the integrated resources are interpreted to meet the product information requirements of specific applications. The interpretation is achieved by selecting appropriate resource constructs and refining their meaning, by specifying any appropriate constraints, relationships, and attributes. This interpretation results in an application interpreted model. The application interpreted model is documented as part of an application protocol.

Wherever a resource construct is used to represent the same information requirement in different application protocols, the same interpretation of the resource construct is used. The scope and information requirements of the application are specified in the terminology of the application. The application protocol provides a mapping to show how the interpretation of the integrated resources is used to meet the information requirements of the application.

4.2.3 Implementation methods

Each implementation method included in ISO 10303 is specified by a mapping from the *EXPRESS* language onto the formal language used for the method. The mapping is independent of the application protocol. The mapping is expressed in a formal notation. At least three implementation methods for ISO 10303 have been identified.

4.2.4 Implementations

An application protocol may specify one or more applicable implementation methods from the set of implementation methods in ISO 10303. An implementation shall apply one or more of the implementation methods specified in the application protocol to the application interpreted model.

4.2.5 Conformance testing

Conformance of an implementation to an application protocol is specified by the conformance requirements in the application protocol.

A set of tests, specified in an abstract test suite, is defined for each application protocol. When associated with an abstract test method, these tests may be used to assess the conformance of an implementation. The overall framework for conformance assessment is specified in ISO 10303-31.

An abstract test method for each implementation method is specified in one of the conformance testing methodology and framework series of parts of ISO 10303.

The scope of conformance testing of a specific implementation is the requirements specified for the conformance class(es) claimed for the implementation in the Protocol Implementation Conformance Statement. The tests are selected from the abstract test suite, based on the conformance class claimed by the implementation. Test results provide the basis for conformance assessment.

ISO 10303 contains abstract test suites and defines abstract test methods for performing conformance testing to provide a basis for test results that are repeatable, comparable, and auditable. Inclusion of conformance testing procedures in ISO 10303 is intended to promote widespread acceptance of test results.

4.3 Information object registration

In order to provide unambiguous identification of schemas and other information objects in an open information system, this International Standard employs the registration technique defined in ISO/IEC 8824-1. This technique identifies objects by their assignment to a tree structure whose root is ISO itself. Each node in the tree is identified by a sequence of integers corresponding to the index of the leaf under each node. Nodes that identify agencies that can further specify inferior nodes are called registration authorities. There is provision in this technqiue for having registration provided by national bodies and other identified organizations (including private corporations). A registration authority is automatically granted to the technical committee or

subcommittee that prepares a standard in order to identify objects within the standard. Thus, ISO 10303 is identified by the object identifier:

```
{ 1 0 10303 }
```

Here the initial 1 indicates ISO; the 0 following it identifies the object as a standard, and the number following that is the number of the standard. ISO/IEC 8824-1 also defines identifiers to stand in the place of these numbers; thus 'iso' has the value 1 and 'standard' has the value 0. For multi-part standards, the next number is required to be the part number. Thus, this part of ISO 10303 is identified by the object identifier:

```
{ iso standard 10303 part(1) }
```

Here, the value of the part number is given explicitly, but the notation allows us to associate a term with this value, thereby providing some semantics. The notation for values of this type is defined in clause 28 of ISO/IEC 8824-1, and the predefined assignments are specified in annex B of ISO/IEC 8824-1.

For the purposes of identifying information objects unambiguously within an open information system, ISO 10303 adopts the following conventions:

– The value following the part number shall be version number. By convention, the value of the version number of the first edition shall be 1. The value 0, if used at all, is reserved to refer to DIS documents.

– The value following the version number is used to identify the type of information object defined within the part. The value 1 shall indicate that the object so identified is a schema.

– The value following the object type is an integer that identifies the instance of the object type so identified.

– To meet the syntactic requirements of ISO/IEC 8824-1, replace each occurrence of a low line in a schema name with a hyphen when defining this value.

EXAMPLE 1 – In ISO 10303-41, several schemas are defined. The application_context_schema can be identified by the value

```
{ iso standard 10303 part(41) version(1) object(1) application-context-schema(1) }
```

and the product_definition schema can be identified by the value

```
{ iso standard 10303 part(41) version(1) object(1) product-definition-schema(2) }
```

5 Structure of ISO 10303

ISO 10303 is divided into six series of parts. Each series has a unique function. Each series may have one or more parts. The series are listed below with their numbering scheme:

– Description methods - Parts 11 to 19;

- Integrated resources:
  - Generic resources - Parts 41 to 99;
  - Application resources - Parts 101 to 199;
- Application protocols - Parts 201 to 1199;
- Conformance testing methodology and framework - Parts 31 to 39;
- Abstract test suites - Parts 1201 to 2199, corresponding to the associated application protocols 201 to 1199;
- Implementation methods - Parts 21 to 29.

6 Description methods

The description of product data in integrated resources and application protocols requires the use of formal data specification languages to ensure consistency and avoid ambiguity. The languages are intended to be both human-readable to facilitate human understanding and computer-interpretable to facilitate the generation of application software and supporting tools.

6.1 The EXPRESS language

EXPRESS is a formal data specification language, specified in ISO 10303-11, that provides the mechanism for the normative description of product data for both integrated resources and application protocols.

EXPRESS allows a description of the data and constraints applicable to product data. *EXPRESS* permits the definition of resource constructs from data elements, constraints, relationships, rules and functions. The language permits classification and structuring of resource constructs. Resource constructs may be interpreted within application protocols. The interpretation capability of *EXPRESS* is a mechanism to facilitate the development of application protocols by allowing the addition of restrictions on attributes, the addition of constraints, the addition of relationships among resource constructs and application constructs, or all of the above.

6.2 Graphical presentation of models

The graphical presentation of models to illustrate normative data definitions is informative in all cases. The four types of models within this International Standard using graphical presentations are:

- resource constructs within integrated resources;
- application activity models;

- application reference models;

- application interpreted models.

Graphical presentations are provided to aid in understanding the definitions presented in each part. Different graphical presentations that are used within ISO 10303 include:

- *EXPRESS-G* - The graphical representation of *EXPRESS* as defined in annex D of ISO 10303-11.

- IDEF0 - An activity modelling notation [2] used for application activity models within application protocols.

- IDEF1X - The graphical representation used in the IDEF1X information modelling method [3].

- NIAM - The graphical representation used within the NIAM information modelling method [4].

7 Integrated resources

The integrated resources provide resource constructs that are used as the basis of representation of product data. The integrated resources are interpreted to support the information requirements of applications.

Integrated resources provide a unique representation of each element of information within ISO 10303. The meanings of the resource constructs are provided through text definitions.

The integrated resources are divided into logically-related sets of one or more resource constructs. The generic resources are context-independent. The application resources are applicable to specified ranges of applications.

Examples of the two types of integrated resources include:

Generic resources:

- Fundamentals of product description and support (ISO 10303-41);

- Geometric and topological representation (ISO 10303-42);

- Representation structures (ISO 10303-43);

- Product structure configuration (ISO 10303-44);

- Visual presentation (ISO 10303-46);

Application resources:

– Draughting (ISO 10303-101);

Generic resource constructs may be interdependent to avoid duplication. Application resource constructs may reference generic resource constructs.

8 Application protocols

8.1 Definition of application requirements

An application protocol (AP) includes the definitions of scope, context, and information requirements of an application. The definitions may specify functions, processes or information that are excluded from the application in order to clarify the scope, context, and information requirements. The statement of scope is supported by an application activity model (AAM) that describes the processes, information flows, and functional requirements of the application. The activity model is included as an informative annex to the AP.

The information requirements and constraints for the application context are defined by means of a set of units of functionality and application objects using application-based terminology. This definition is derived from an application reference model (ARM). An ARM is a formal information model that is documented in an informative annex to the AP.

8.2 Information representation

The resource constructs for representing the information requirements of the application are specified in an application interpreted model (AIM) using the *EXPRESS* language. The AIM is assembled from resource constructs specified by the integrated resources. The resource constructs are interpreted to meet the application requirements within the defined context and scope of the AP.

A mapping from the information requirements to the AIM is provided. The mapping defines the use within the AIM of resource constructs from the integrated resources to represent the information requirements of the application.

8.3 Implementation methods

The AP is independent of implementation methods. However, an AP may include implementation method specific information in a normative annex. An AP includes a table of short names that the exchange structure implementation method uses to encode AP entity names.

8.4 Conformance requirements

An application protocol includes the conformance requirements to be satisfied by any implementation claiming to support the requirements of the AP. Conformance requirements reflect the

capabilities defined in an AP and may be specified in the description methods, implementation methods, or application protocol series of parts of ISO 10303.

9 Conformance testing methodology and framework

9.1 Purpose of conformance testing

The conformance testing methodology and framework series of this International Standard provides the general methodology and requirements for the process of testing the conformance of a product that claims to implement an ISO 10303 application protocol. The goal of the methodology and framework of conformance testing is to ensure:

- Repeatability: test results are consistent whenever undertaken;
- Comparability: test results are consistent wherever undertaken;
- Auditability: test procedures can be confirmed as having been correctly undertaken, subsequent to the testing, by review of record.

ISO 10303-31 provides a framework and describes the general concepts for conformance testing of implementations of ISO 10303.

9.2 Procedures for conformance testing

Conformance testing of an application protocol can be performed by applying the abstract test method for the chosen implementation method to the test cases in the abstract test suite. The procedures for conformance testing are independent of the implementation under test.

If a single implementation combines several application protocols, conformance testing is performed for each application protocol separately.

ISO 10303 defines the roles and responsibilities of the testing laboratory and the client submitting an implementation for conformance testing.

9.3 Abstract test methods

ISO 10303 specifies an abstract test method for each implementation method. The abstract test method describes how an implementation of a particular implementation method is to be tested, independent of:

- the particular implementation;
- the testing tools and procedures;
- the specific application protocol under test.

10 Abstract test suites

An abstract test suite contains the set of abstract test cases for an application protocol to support the conformance requirements. Each abstract test case provides an implementation-independent specification of the actions required to evaluate part of one or more conformance requirements. Each application protocol contains a normative reference to the corresponding abstract test suite.

Each conformance requirement corresponds to one or more abstract test cases, designed to satisfy one or more test purposes. For each abstract test case, verdict criteria are generated from the conformance requirements to allow a testing laboratory to assess the conformance of an implementation with respect to that test case. When a conformance test based on an abstract test case is conducted, the resulting verdict indicates if the implementation meets one or more conformance requirements.

11 Implementation methods

11.1 Purpose

ISO 10303 provides for various methods of implementation. An implementation method provides a particular way of using the application protocols defined in ISO 10303. ISO 10303-21 specifies an implementation method for an exchange structure. The exchange structure provides for the writing and reading of the description of product data in application protocols, using clear text or binary encoding.

11.2 Use of formal language

An implementation method is defined using a formal language so that computer-based methods may be used for the development of implementations.

11.3 Mapping from EXPRESS to implementation method

EXPRESS provides the basis for all specifications of product information in ISO 10303. Each implementation method defined in ISO 10303 specifies mapping rules from the syntax of *EXPRESS* onto the language used for the implementation method. The structure and syntax of each resource construct as it appears in the implementation is derived by applying the mapping rules. The rules to be applied for a particular implementation method may be conditional on the form of the *EXPRESS* definition that is being mapped. Any schema defined in *EXPRESS* can be mapped to the implementation method.

11.4 Exchange structure implementation

The syntax and mapping rules for the exchange structure using clear text encoding are specified in ISO 10303-21. The exchange structure may be implemented to support file exchange. The language used for the syntax of the exchange structure implementation method is based on Wirth Syntax Notation [5]. The mapping from *EXPRESS* to the syntax of the exchange structure is defined.

Annex A
(normative)
Information object registration

In order to provide for unambiguous identification of an information object in an open system, the object identifier

```
{ iso standard 10303 part(1) version(1) }
```

is assigned to this part of ISO 10303. The meaning of this value is defined in ISO/IEC 8824-1 and is further described in 4.3.

Annex B
(informative)
Bibliography

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